Development of Sensors for Automotive PEM-based Fuel Cells

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Development of Sensors for Automotive PEM-based Fuel Cells

- Contractor: International Fuel Cells
- Subcontractors to IFC
  - ATMI
  - NexTech Materials
  - Illinois Institute of Technology (IIT)
  - UTRC
- Project Duration: 36 months
- Total Cost: $3.5M; DoE Cost: $2.8M
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Sensor Program Objectives

- Sort the market of commercially available sensor technologies and qualify those which are currently ready or adaptable to PEM fuel cell application.
- Develop a supplier base from which IFC can obtain needed sensor technologies.
- Partner with companies to develop and commercialize required sensors.

Desired Sensor Characteristics for Modern Automobiles

- A specific design, evaluated, and commercially available with high performance is needed with the following characteristics
  - Survivability (> 5000 operating hours).
  - Sensitivity and Quick Response.
    - CO: three ranges, 0.1 to 1 sec response
    - H_2: 0.1 - 100%, < 1 second response
    - Sulfur Compounds: 0.05 - 0.5 ppm, < 1 min. response
    - NH_3: 1 - 10 ppm, response time in seconds
    - O2: 0 - 50%, < 0.5 second response
    - Physical Sensors: 30-75% H_2, CO_2, N_2, H_2O, CO environment at up to 3 atmospheres pressure.

Sensor Needs and Requirements for Fuel Cell Vehicles*

- Chemical sensors
  - Process streams: before, in, and after reformer, before and in fuel cell stack: CO, H_2, O_2, H_2S, NH_3.
  - Safety [H_2].
  - Response times compatible with function being monitored.
- Physical-parameter sensors - process only
  - Mass flow; temperature [thermocouples (70-90ºC)]; pressure; relative humidity; level and flow switches.

* based in part on: DOE Workshop; “Sensor Needs and Requirements for Fuel Cells and CIDI/SIDI Engines," Robert S. Glass, Ed., published by Lawrence Livermore National Laboratory , April, 2000.

Sensor Program Milestones

TASK	MILESTONE #	MILESTONE	MILESTONE DATE
Physical Sensor Development	1	Sensor Performance Review	11/01/02
	2	Proto Delivery to IFC	04/01/03
Electrochemical Sensor Development	3	Sensor Performance Review	10/01/02
	4	Proto Delivery to IFC	03/01/04
MEMS Sensor Development	5	Sensor Performance Review 1	10/01/02
	6	Sensor Performance Review 2	05/01/03
	7	Sensor Performance Review 3	10/01/03
	8	Proto Delivery to IFC	05/01/04
Independent Validation	9	Sensor Suite Delivery to DOE	9/3/2004

Requirements: Physical Parameter Sensors

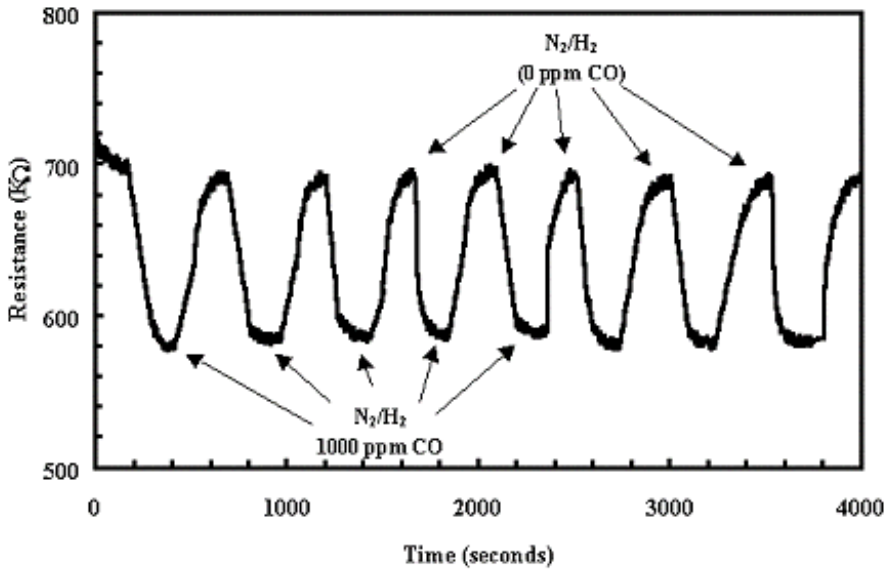
Sensor Types	Measurement Range	Operational Temperature	Response Time	Accuracy	Gas Environment
Flow rate sensors (in-stack)	**30 – 300 L/min**	**80 °C**	**N/A**	**N/A**	**High humidity and reformer exhaust. H_2 at 30 – 75 % with CO_2, CO, N_2, H_2O at 1 –3 atm total pressure and trace NH_3, H_2S, HC.**
Temperature sensors (pre-stack, ambient)	**-40°C / +150°C**	**N/A**	**< 0.5 sec at -40 – 100 °C < 1 sec at 100 – 150 °C**	**1.5 % at -40 – 100 °C 2% at 100 – 150 °C**	
Relative humidity sensors (pre-stack, ambient)	**20 – 100 %**	**30 °C – 110 °C**		**1 %**	
Differential pressure sensors* (pre-stack)	**0 – 1 psig (or 0 – 10 & 1 – 3 psig)**	**30 °C – 100 °C with -40 °C survivability**	**< 1 sec**	**1 %**	

*** Size: 1 square inch and without orientation problem**

*** Must be able to withstand and measure both liquid and gas phases**

Electrochemical Sensors

- NexTech Materials
  - CO, SO_2, H_2S, and NH_3
  - Demonstrated sensitivity for ppm CO in 75% H_2



Effect of carbon monoxide (1000 ppm) on resistance of NexTech sensor in a baseline gas composition of 50% hydrogen and 50% nitrogen.

MEMS Sensor Development

- ATMI
  - H_2, SO_2, H_2S, NH_3.
  - Patented micro hotplate for H_2 detection.